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DOD RESEARCH PROGRAM IN ROBOTICS

BY JOHN M. VRANISH

ENGINEERING DEPARTMENT

10 SEPTEMBER 1980

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This paper is a broad, brief overview of the DOD Research Program in Robotics. It begins with background examples on some of the needs and current robotic techniques being used in DOD activities. It then discusses near future robotic systems currently projected for funding. Next, projections are made for the more far-term future DOD robotic systems. Finally, specific areas requiring research are delineated and Navy research programs are identified which address these areas.

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FOREWORD

This report documents the NSWC perception of the DOD Research Program in Robotics. It was written in response to a request from the Plans and Operations Office of the Department of the Army, Harry Diamond Laboratories (HDL), Adelphi, Maryland. HDL also provided scope and content guidance. This report takes a broad view and considers all three services. Current applications and near-future projections are examined, in addition to the more far-term 6.1 efforts. In discussing these 6.1 efforts, specific research projects are listed which are typical of the important areas of robotics, thus providing the reader with a clear picture of the overall direction of the DOD Research Program. The author gratefully acknowledges the assistance of Mr. Marvin Denicoff, Office of Naval Research.

T.R. McKNIGHT
By direction

CONTENTS

ILLUSTRATIONS

DOD RESEARCH PROGRAM IN ROBOTICS

1. WHAT IS A ROBOT

Of the several current definitions, the following is as inclusive as any: "A machine that can duplicate human skills and flexibility with accuracy and precision."[1] Robotics technology in industry is driven primarily by the need to achieve flexible, low cost/high productivity automation. American industry today has 3,000 robots in use; Japanese industry utilizes 7,000. By 1995, the Society of Manufacturing Engineers predicts that 50% of automobile assembly will be accomplished by automated machines and robots.[2]

2. HOW DO ROBOTS IMPACT DOD

DOD has all of the cost/productivity/worker morale problems of industry plus a few special problems of its own. Not only must DOD manufacture systems, it must also support and maintain these systems across a far-flung theater of operations in frequently hostile operating environments, using a largely unskilled labor force that has a high turnover rate. Thus, the demand for intelligent, flexible automation (robots) is obvious.

a. PRESENT. All three DOD services are starting with the problem of production - the simplest starting point. The Air Force ICAM (Integrated Computer Aided Manufacture) project is the most visible and is addressing aircraft manufacture. Figure 1[3] illustrates work on the F-15 fighter. The Army is also using industrial robots for:

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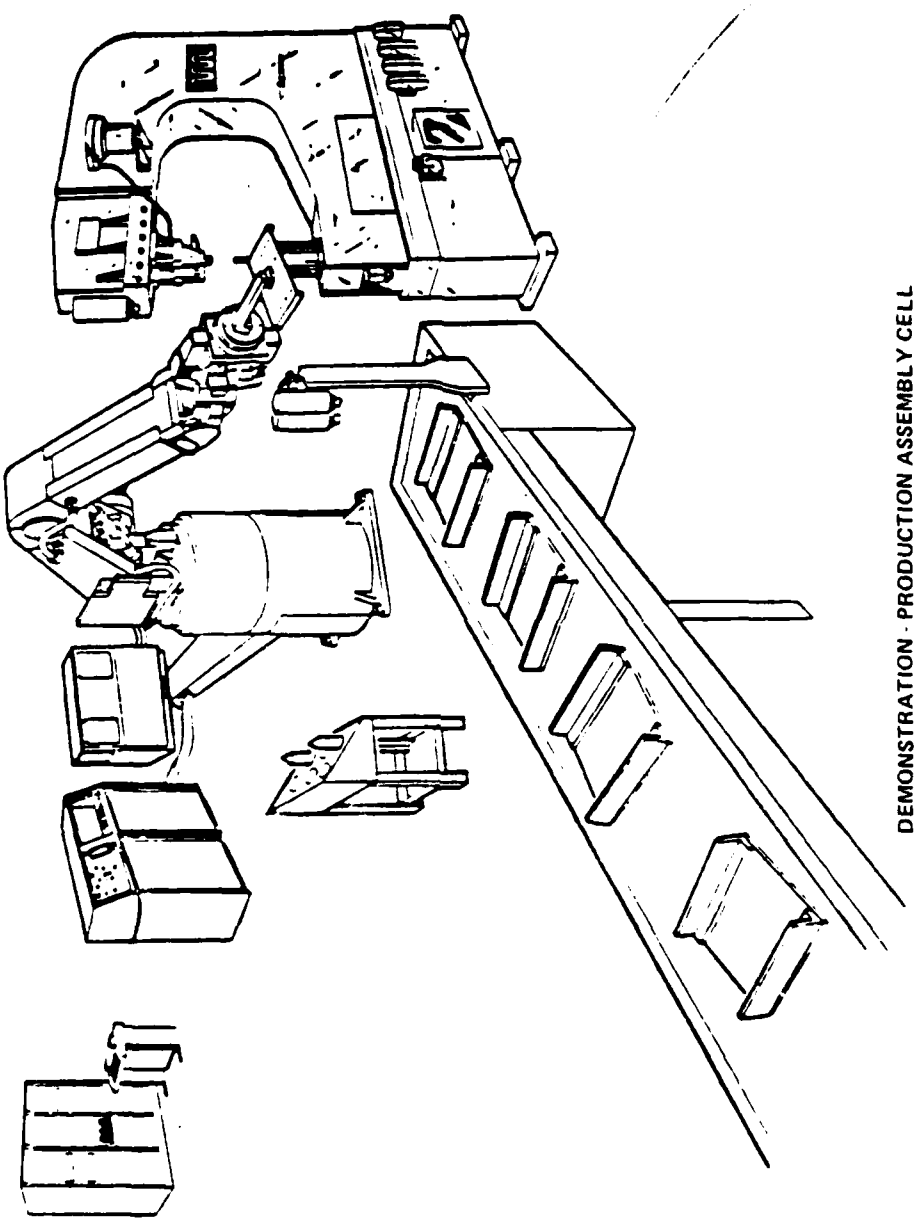
[1] Industrial Robots, Vol. I/Fundamentals; Copyright 1979 SME, Dearborn, Mich. 48148.

[2] NEXT Magazine, May/June 1980, p. 32.

[3] Robotic System For Aerospace Batch Manufacturing. IR-812-8(1) First Quarterly Tech. Report, Nov. 1978 by Air Force Materials Lab. Wright-Patterson Air Base, p. 3.23.



DEMONSTRATION - PRODUCTION ASSEMBLY CELL

FIGURE 1 ROBOTIC SYSTEM FOR AEROSPACE BATCH MANUFACTURING

(1) robotized benching operations[4] and loading of Numerical Control Machines For Cannon and Breach Manufacture;[5] and (2) automated munitions handling.[6]

b. NEAR TERM. The use of robots in DOD systems manufacturing will continue to escalate in parallel with industry. Depot and intermediate maintenance activities will begin to use robots as the technology matures to the point where robots can deal with the complications and variations associated with maintenance and repair. An example of this is the Navy Robotic Deriveter which is scheduled for a 2-year development program commencing in FY 81. This robotic system will use an ultra-sonic sensor and "common sense artificial intelligence" to figure out the rivet pattern, and rapidly inspect (the airframe structure around each rivet) and remove the rivets. This flexible system will be able to handle several different sizes of rivets in a variety of patterns on many different aircraft types. (Deriveting in the Navy is necessary because of salt water corrosion damage to airframes.) Figures 2a and 2b illustrate the Robotic Deriveter.[7]

c. FAR-TERM. Robots will be developed for DOD field uses to assist combat and support forces. These field applications will place still greater requirements on robots to be more flexible, intelligent and to have sensory capabilities. An example is the Office of Naval Research suggestion that much of the maintenance on board ship can be done more efficiently by using a work cell operated by intelligent robots to manufacture parts on a need-basis rather than carrying vast numbers of spares which are seldom or never used.

3. WHAT RESEARCH IS NEEDED

Clearly, research is needed that will improve: (a) the sensory capabilities of robots (specifically artificial recognition); (b) the thinking capability of robots (specifically artificial intelligence*); and (c) the motor and physical dexterity capabilities of robots (such as the tendon research being done at MIT).

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[4] Manufacturing Methods and Technology, Program Plan CY 1979, U.S. Army Industrial Base Engineering Activity, Rock Island, Illinois, p. 68.

[5] Ibid; p. 61.

[6] Ibid; p. 39.

[7] Vranish, J.M., "The Robotic Deriveter - Systems Concept," NSWC TR 80-353, Sep 1980.

* Artificial Intelligence allows Robots to exhibit intelligent behavior without resorting to massive computers and computational capabilities.

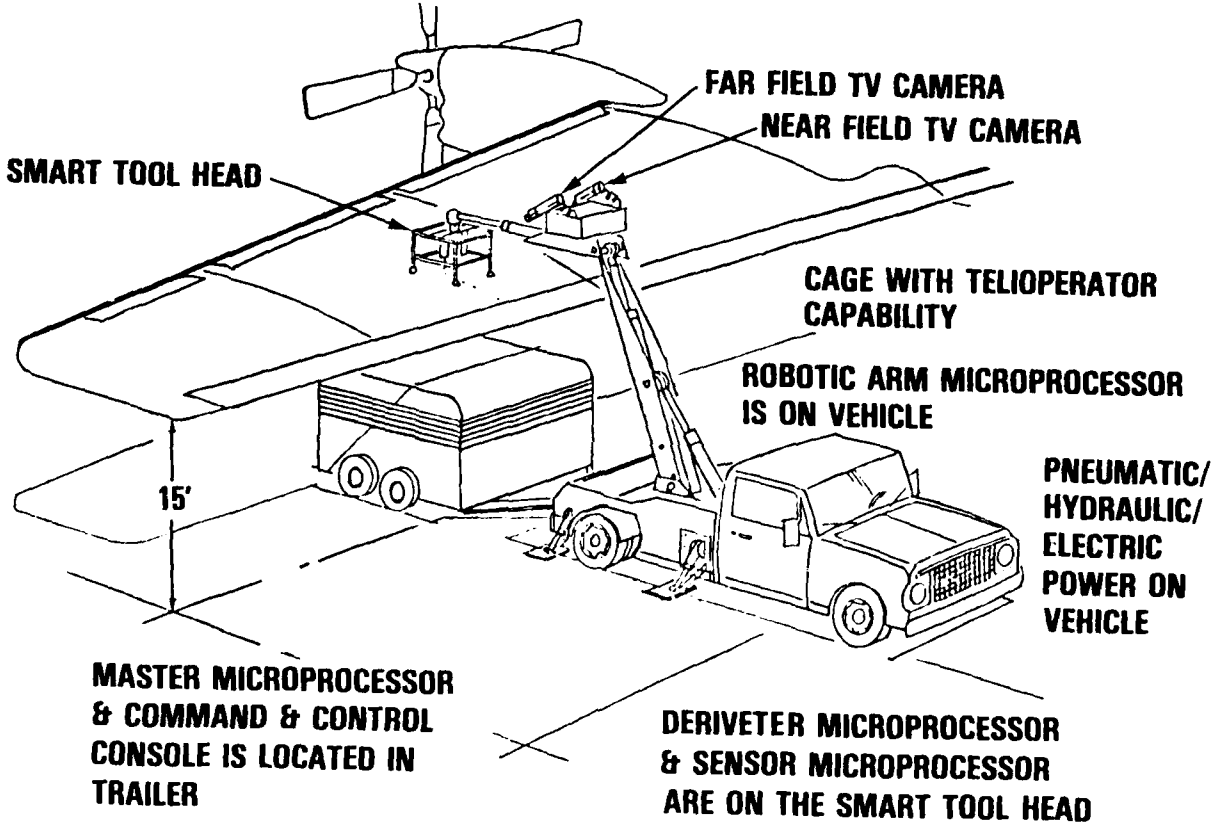

FIGURE 2a ROBOTIC DERIVETER SYSTEM CONCEPTUALIZATION

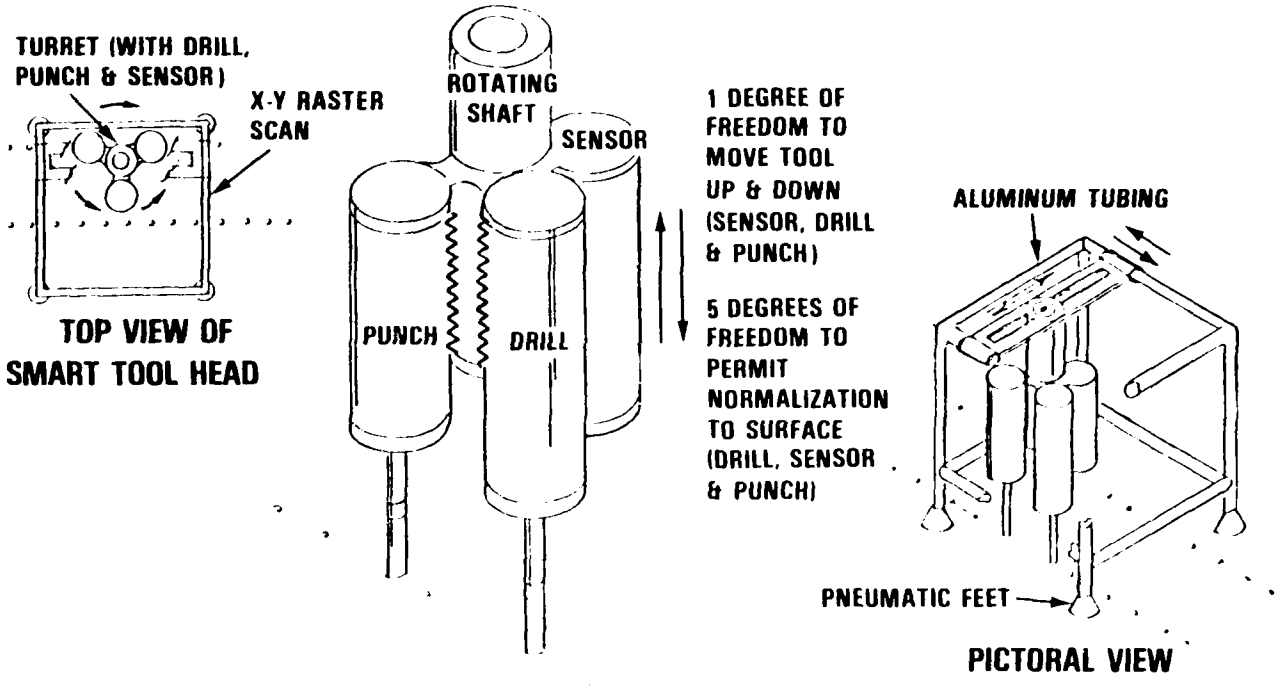

FIGURE 2b SMART TOOL HEAD CONCEPTUALIZATION

4. WHAT RESEARCH IS BEING DONE

Many DOD 6.1 research thrusts and projects are being pursued, some of which are listed below:[8]

a. SENSORY CAPABILITIES OF ROBOTS AND MAN-MACHINE INTERFACES.

(1) Context Pattern Recognition - Prof. Riseman, University of Massachusetts. (General).

(2) Sketch Recognition (Vision) - Prof. Negroponte, MIT.

(3) Natural Language Interaction (Speech) - Prof. Schank, Yale University.

(4) Linguistics Pattern Theory (Speech) - Prof. Freiberger, Brown University.

(5) Image Modelling Workshop (Vision) - Prof. Rosenfeld, University of Maryland.

(6) Speech/Picture Processing (Speech/Vision) - Prof. Oppenheim, MIT.

b. THE THINKING CAPABILITY OF ROBOTS.

(1) Intelligent Automata - Prof. Winston, MIT.

(2) Evaluation Artificial Intelligence Algorithm - Prof. Harrison, New York University.

(3) Knowledge - Based Problem Solving - Prof. Minskey, MIT.

(4) Distributed Problem Solving - Prof. Lesser, University of Massachusetts.

(5) Automated Knowledge Acquisition - Prof. Reddy, Carnegie Mellon University.

(6) Complex Textual Problem Solving - Prof. Charniak, Brown University.

(7) Complex Planning and Action System - Prof. Sacerdoti, SRI International.

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[8] Active Contracts, Office of Naval Research; Information Science Program, 31 Dec 1979.

c. THE MOTOR AND PHYSICAL DEXTERITY OF ROBOTS.

(1) Robot Tendon Research - Prof. Horn, MIT.

(2) Automated Maintenance - Prof. Feldman, University of Rochester.

(3) Distributed Robot Command and Control - Prof. Nilsson, SRI International.

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